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PRESSURE HYDROMETALLURGY APPLIED TO LOW-GRADE ORES

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PRESSURE HYDROMETALLURGY APPLIED TO LOW-GRADE ORES

T.R. Scott[1]

INTRODUCTION

1. There is no need for pressure hydrometallurgy to be confined to highly industrialized areas. Today pure alumina is being made from bauxite in the West Indies, South America and West Africa by one of the oldest and best-known processes of pressure hydrometallurgy, viz. the Bayer process using caustic soda at temperatures of 150 and 160°C. Likewise, pressure digestion of complex lead, zinc and copper ores is being initiated in the Philippines, using ammoniacal solutions, while a complex operation using sulphuric acid under pressure for the recovery of nickel has been set up in Cuba. This paper will describe briefly the scope and advantages of pressure hydrometallurgy and will illustrate by a few examples the possibilities of treating low-grade ores.

ADVANTAGES AND SCOPE

2. The major advantages of pressure hydrometallurgy are that reactions are faster and the products of reaction are often different, in comparison with operations at ordinary temperatures. It is not proposed to give an extensive bibliography since two excellent reviews have appeared in the past ten years[2,3] and further up-to-date references will appear in the A.I.M.E. Symposium on "Unit Processes in Hydrometallurgy" to be held in Dallas, Texas, U.S.A., in February 1963.

3. The scope of pressure hydrometallurgy is limited only by expense. There are many operations (e.g. cyanidation of gold ores) which are sufficiently effective at ordinary temperatures and which would not require or warrant the use of pressure techniques. Moreover, corrosion problems, especially in acid environments, are more serious at high temperatures and pressures, so that materials of construction are liable to be relatively costly in certain circumstances.[4] Nevertheless, as the following examples will show, there are many instances where great benefit can accrue from the application of high pressures and temperatures in the treatment of low-grade ores. Cost of special equipment is more than compensated by the speed of reaction and the consequent high throughput which can be realized.

EXAMPLES OF PROCESSES

4. The alkaline process used by Sherritt Gordon Mines Ltd. at Fort Saskatchewan, Alberta, Canada, is an outstanding example of a procedure which can be applied to a variety of sulphide ores, irrespective of grade in many instances. It is also of interest in that ammonia under pressures of 100-110 p.s.i. is used to form the soluble amines of nickel, cobalt and copper, although temperatures are only in the region of 80-90°C. By comparison, at a later stage in the process nickel is precipitated as metal using hydrogen at 500 p.s.i. and at temperatures up to 200°C. A distinction can thus be drawn between pressure due to added gases and steam pressure due to operation in aqueous solutions at temperatures above 100°C.

5. The mineral pyrite (FeS_2) is only attacked very slowly by dilute acid at room temperatures, yet at 180°C in the presence of air or oxygen it is rapidly oxidised to form ferric sulphate, which in turn is simultaneously hydrolysed to form ferric oxide and sulphuric acid.[5] Hence pyrite in low-grade ores can be used as a cheap source of sulphuric acid which can be used simultaneously to dissolve small amounts of uranium,[6] copper, nickel etc., which may be present in the ore. This type of process is particularly suitable where sulphuric acid itself is expensive, where the gangue minerals in the ore are relatively unreactive, and where the valuable minerals in the ore are difficult to recover by physical methods of ore-dressing. The principle can naturally be extended to low-grade mixtures of many other sulphide minerals which are not responsive to the more conventional methods of concentration.

6. When sulphuric acid is relatively cheap it can be used partly expendably for the treatment of low-grade ores, such as the nickeliferous laterite occurring in large deposits in Cuba. Here the Freeport Nickel process[7] was used to treat economically an ore containing only 1.35% Ni and 0.13% Co. The material also contained large amounts of iron and aluminium which were readily soluble at ordinary temperatures in dilute acids, but by operating at 230°C and at pressures up to 500 p.s.i., remarkably selective leaching of nickel and cobalt was achieved in short treatment series. This example serves to demonstrate that advantage can be taken of the large changes in solubility of some metallic sulphates at elevated temperatures.

7. In contrast to the above example some ores become more reactive at high temperatures. This applies to a variety of aluminous ores, such as bauxite, calcined clays etc., and has been used both in the Bayer process (using caustic soda) and in a new acid process.[8] With sulphuric acid as the solvent high recoveries of alumina can be obtained at temperatures around 180°C in only 30 minutes and, by using a suitable 2-stage digestion process, iron contamination of the aluminium sulphate solutions can be reduced to a sufficiently low level for subsequent processing. The major advantage of this acid process is that it can be applied to low-grade bauxites which contain too much silica for economic treatment by the conventional Bayer process.

8. The effect of temperature on the stability of solutions can also be put to good use. With ferric and aluminium sulphates solutions which are quite stable at ordinary temperatures hydrolyse readily above 100°C and thus enable separations or recoveries to be made. In the case of aluminium a pure basic aluminium sulphate can be recovered in 60% yield by heating the appropriately treated solution[9] for only 10 minutes at 220°C. If residual iron is present in the ferrous state, advantage can be taken of the fact that this salt does not hydrolyse under the operating conditions and a pure aluminium compound can thus be recovered.

CONCLUSIONS

9. Even with the few examples given, it is clear that pressure hydrometallurgy as a technique opens up new fields of chemistry, particularly as regards the treatment of otherwise refractory material and the opportunities for making useful separations not feasible at lower temperatures. In the writer's experience it has also been found that the reaction mixtures produced at high temperatures tend in many instances to filter or settle better than their counterparts at lower temperatures. In addition, the speed and very often the selectivity of reactions favour the use of pressure hydrometallurgy in many fields where low-grade ores are difficult to treat; despite the need for closer control and more elaborate equipment. In view of the successful commercial operation of several of the examples cited, it is evident that the cost of working at high temperatures and pressures is no barrier to the development of useful processes.

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